



# Minerals in Afghanistan

## The Hajigak iron deposit

### Introduction

The Hajigak iron ore deposit is situated in the mountainous Bamyan province, 130 km west of the Afghanistan capital, Kabul (Figure 1). It is one of several iron deposits within this area but is the largest located to date. The ore occurs within the Herat fault zone as sub-concordant sheets and lenses within Proterozoic metasedimentary and metavolcanic rocks. A study in the 1960s

demonstrated the mineral potential of the region, and estimated the Hajigak resource as 1.8 billion tonnes of iron ore with a concentration of approximately 62 % Fe (Table 1). This assessment ranks the Hajigak deposit as world class. The presence of coking coal nearby at Shabashak and the world-class ranking of the iron ore resource combine to make the Hajigak deposit an exceptionally favourable target for economic development.



Figure 1. Tectonic map of Afghanistan showing major blocks and faults and location of Hajigak.



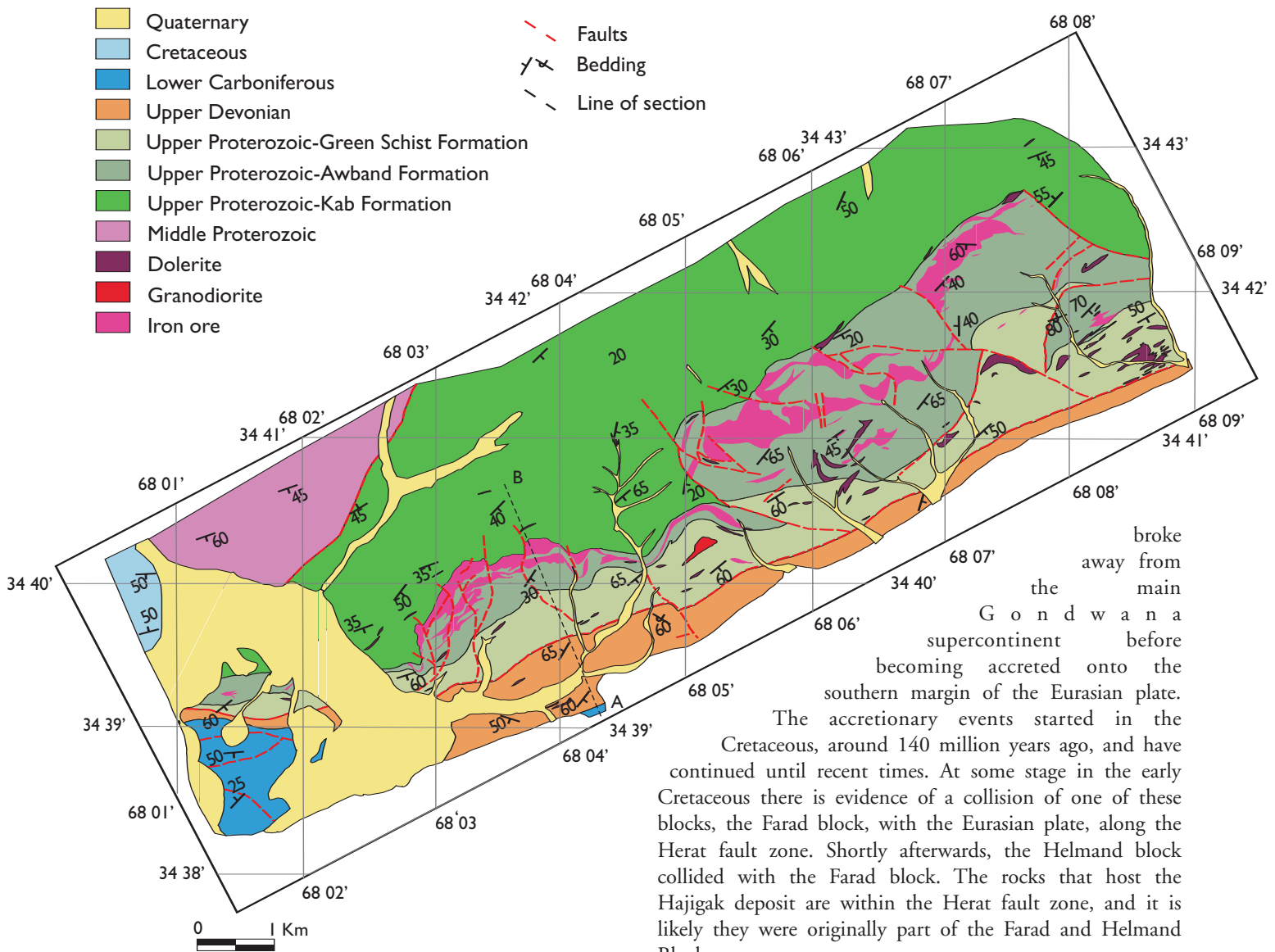


Figure 2. Simplified geological map of the Hajigak area.

### Tectonics of Afghanistan

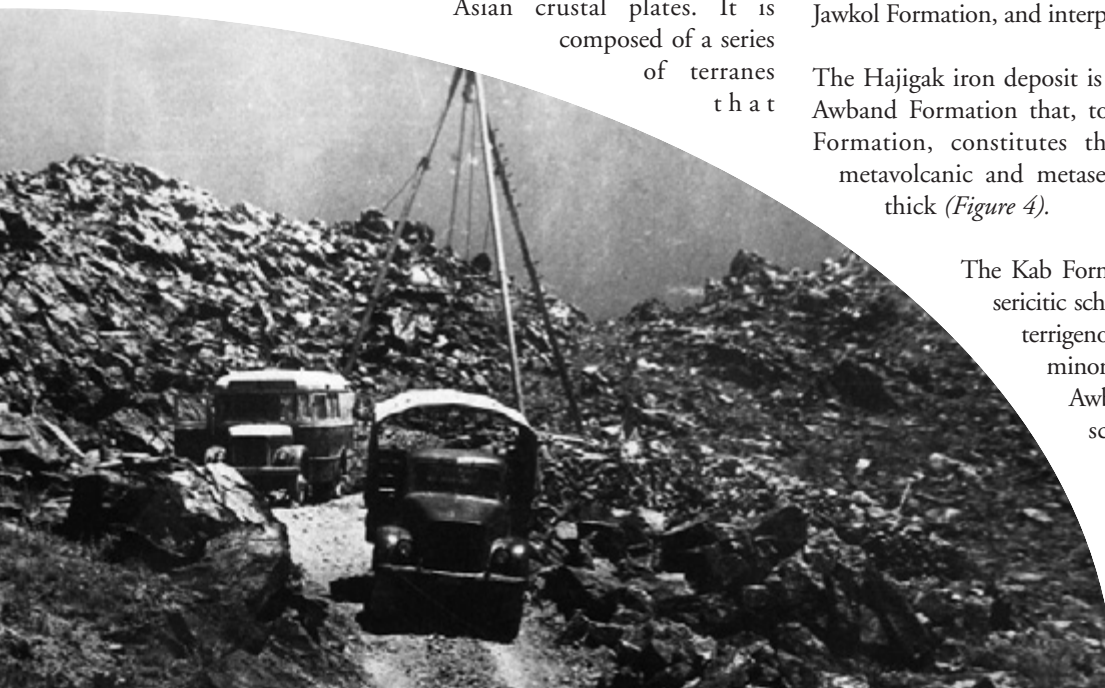
Afghanistan has a complex geology due to its position on the junction between the Indo-Pakistan and Asian crustal plates. It is composed of a series of terranes that

### Geology of Hajigak

The oldest part of the succession crops out north-west of the Hajigak deposits (Figure 2). It consists of grey silicified limestones and dolomites interbedded with dark grey crystalline schists and light coloured quartzites that display evidence of amphibolite grade metamorphism. They are mapped as the Jawkol Formation, and interpreted as Middle Proterozoic in age.

The Hajigak iron deposit is hosted by the Upper Proterozoic Awband Formation that, together with the underlying Kab Formation, constitutes the Qala Series, a sequence of metavolcanic and metasedimentary rocks up to 4500 m thick (Figure 4).

The Kab Formation consists of dark grey sandy sericitic schists, interpreted as metamorphosed terrigenous rocks, acid volcanic rocks and minor beds of marble and phyllite. The Awband Formation is made up of schists (quartz-sericite, quartz-chlorite-sericite, quartz-sericite-chlorite and carbonaceous-sericite) that are metamorphosed acid and basic





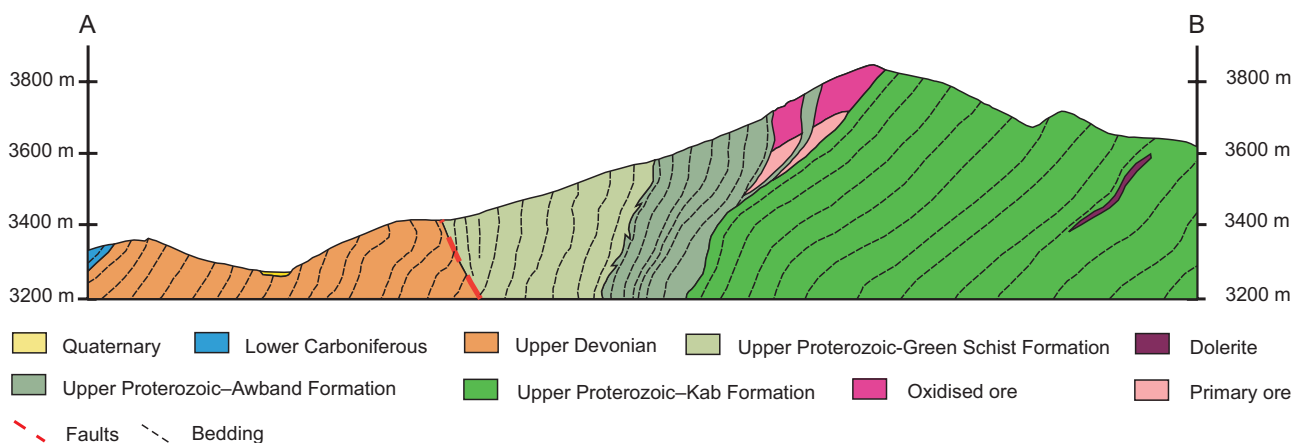


Figure 3. Cross-section through Hajigak iron deposit.

tuffites and argillaceous rocks. Minor cherts and marbles also occur. The Green Schist Formation, a distinctive unit overlying the Awband Formation, consists dominantly of green chlorite schists, and quartz-sericitic schists locally intruded by granodiorites. Some reports consider it as a member of the Awband Formation.

Upper Devonian rocks of the Hajigak Formation are faulted against the Green Schist Formation. Strata of Lower Cretaceous

and younger age crop out in the south west of the area, unconformable on the older sequences.

The predominant strike of the Proterozoic and Palaeozoic rocks is between north-east and north-north-east, with a regional dip of approximately 50° towards the south-south-east or south-east (Figure 3). One major steeply dipping fault juxtaposes the Upper Proterozoic rocks against the crystalline middle Proterozoic rocks. Another throws Upper Devonian rocks against the Upper Proterozoic Green Schist Formation. In addition a suite of north-south and north-west-south-east trending faults, some of them probably thrusts, affect the Upper Proterozoic succession, including the iron ore deposits.

The Upper Proterozoic rocks of the Qala Series are interpreted as being deposited in a slowly subsiding marine basin. The initial basin fill was a variable sequence of sandstones and minor volcanoclastic sediments. Later there was an increase in volcanic activity and exhalative iron-rich fluids formed lenses on the sea floor. These sediments were subsequently altered by burial and low-grade (greenschist facies) metamorphism and became the

Post-Jurassic cover		>600 m	Cretaceous, Neogene and Quaternary cover
Upper Carboniferous		>2500 m	Horzar Formation pelitic schists, quartz rich schists, sandstones, quartzites, conglomerates
Upper Devonian		900 m	Hajigak Formation limestones, conglomerates, sandstones, pelitic schists
Upper Proterozoic		700 m	Green Schist Formation quartz-chlorite-sericitic schists, quartz-chlorite schists, extrusives
		1000 m	Awband Formation quartz-sericitic schists, chlorite-sericitic schists, marbles, quartzites, extrusives, lenses of iron ores
		300–1000 m	
		3500 m	Kab Formation quartz-sericitic schists, phyllites, marbles, altered extrusives lenses
Middle Proterozoic		1000 m	Jawkol Formation crystalline schists, quartzites, silicified limestones and dolomites

Figure 4. Stratigraphic log of the Hajigak area.

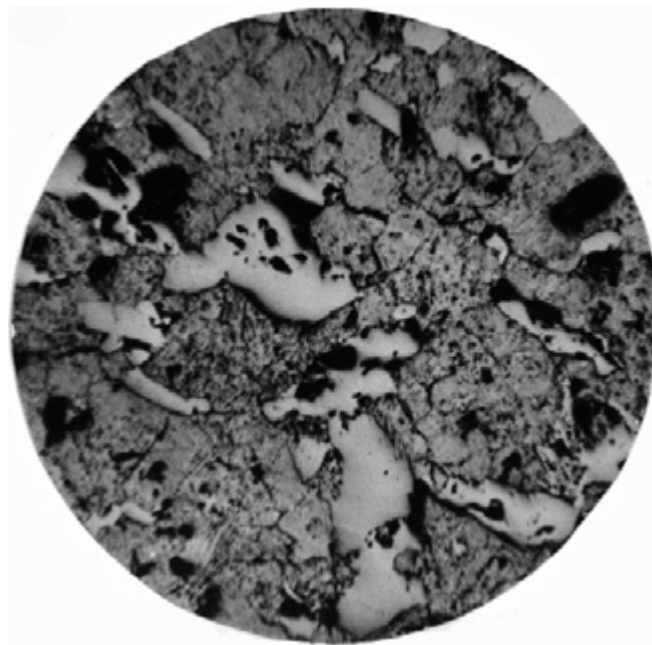


Figure 5. Thin section of Hajigak ore showing hematite and magnetite field of view approximately 1 cm.

basement of the Helmand Block. This block drifted away from Gondwana supercontinent in the Triassic. During the collision with Eurasia, in the early Cretaceous, faulting juxtaposed the Upper Proterozoic Qala series, the Middle Proterozoic rocks and the Upper Palaeozoic rocks. These fault-bounded blocks are a local characteristic of the Herat fault zone. As the collision progressed, the faulted blocks were folded into a north-east–south-west trending anticline the axis of which passes to the north of the area mapped. A series of thrusts developed as indicated by the increased thickness of the iron ore and its host rocks within the central zone at Hajigak. During the final phase of faulting the north–south and north-west–south-east faults that affect the ore deposits were developed. Later post-Cretaceous extension led to the further development of north-west–south-east faults and graben structures filled with young sediments. Subsequent erosion has exposed the core of the Hajigak anticline with the concordant ore bodies on the southeast limb.

### Mineralisation

The Hajigak deposit trends north-east–south-west for about 9 km and is made up of 16 separate ore bodies, each up to 3 km in length. The deposit can be divided up into three geographical parts, the western, central and eastern parts. In addition to the large ore bodies there is a substantial area of thin fragmental ore deposits in the form of four surficial deposits. The main hematitic ore is medium- to fine-grained and displays a variety of massive, banded and porous textures. It occurs in lenses and sheets, within the Awband Formation. The thickness of the lenses has been indicated by drilling to be up to 100 m, while the depth of mineralisation is untested 180 m below surface.

There are two main ore groups: unoxidised primary ores and semi-oxidised ores. The primary ores occur below 100 m and consist of magnetite and pyrite, and up to 5 % chalcopyrite and pyrrhotite. The oxidised ores, extending up to 130 m below ground surface, consist mainly of magnetite, martite and hydrogoethite (*Figures 5 and 7*). Two other oxidised ore types, hydrogoethite/hematite/semi-martite and carbonate/semi-martite, occur sporadically in small amounts in the deposit. Alteration that may be related to the mineralising event has been observed within the host rocks, and includes sericitisation, silicification and carbonisation.

### Exploration

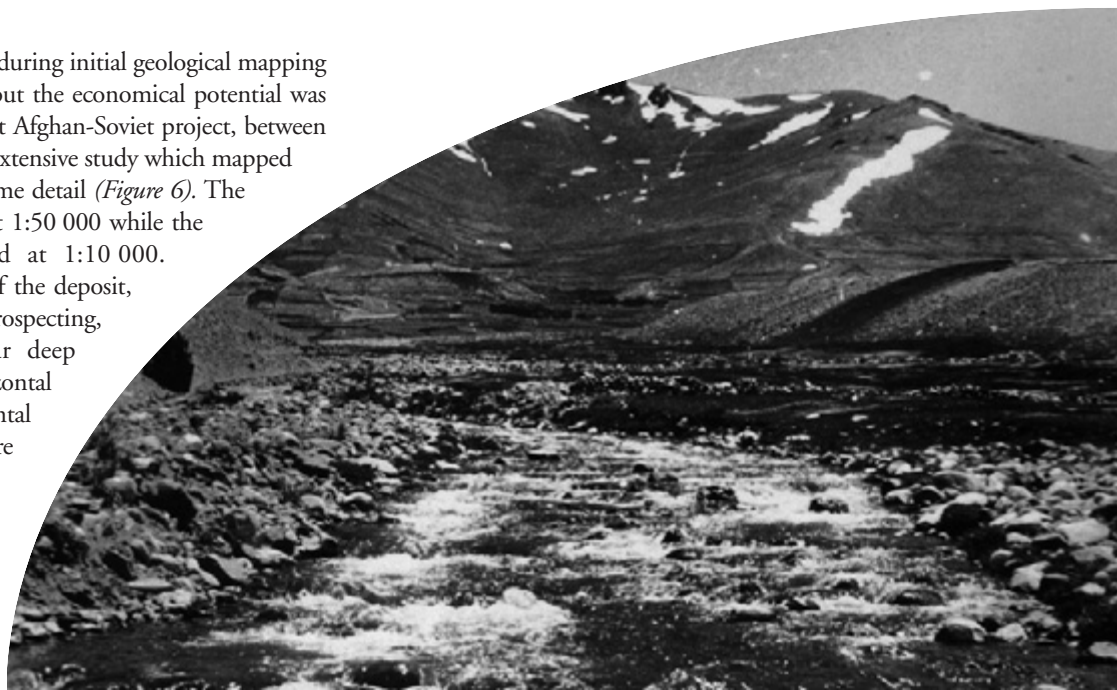
Iron occurrences were observed during initial geological mapping of the area in the mid thirties but the economical potential was not fully recognised until a joint Afghan-Soviet project, between 1963 and 1965, carried out an extensive study which mapped and described the deposit in some detail (*Figure 6*). The regional geology was mapped at 1:50 000 while the Hajigak deposit was mapped at 1:10 000. Focusing on the western area of the deposit, the study included detailed prospecting, trenching, ore sampling, four deep drillholes, a 200 m long horizontal adit and shafts into the fragmental ore. For two of the main ore bodies, I and II, horizontal plans and vertical cross-sections were generated



*Figure 6. Drilling at the Hajigak deposit.*

allowing the ore to be resource classified. Although the ore bodies were thought not to extend to a great depth, there is no deep drilling to confirm this.

Although the study focused on the western section of the ore body, it was of sufficient scope to allow a resource estimate to





be calculated over the entire Hajigak deposit. These calculations were made using the Soviet system and are not easily transferred to western classifications.

#### Metallogenic model

Various models have been suggested for the formation of Hajigak deposit including metasomatic skarn, banded iron formation and submarine-exhalative. It is believed that as the Upper Proterozoic basin evolved there was an increase in the volcanic input to the sediments. Synchronous with this volcanism Fe-bearing hydrothermal fluids were introduced which led to precipitation of iron oxides and sulphides in the form of large sheets and lenses in oxidising shallow water marine conditions. These fluids would have been circulating sea water or magmatic, or a combination of both. Diagenesis and metamorphism converted the iron oxides to the magnetite that is found in the primary ore. Later supergene processes oxidised the ore into hematite and goethite.

#### Future development

The remote and mountainous location of Hajigak makes it a challenging project for future development. However, the large

tonnage and high iron content make it attractive to companies with the proven ability to plan and develop large world-class mines in demanding areas. The deposit remains untested below 180 m and there is a potential for ore at greater depth. Additional prospects and mineral occurrences over a 60 km along strike, at Darrah-i-Nil, Khesh, Zerak, Kharkiza, Surkhi-Parsa, further increase the potential of the area. A feasibility study for the exploitation of the Hajigak deposit was undertaken in 1972 by a Franco-German group, Nenot-Pic. This proposed the construction of a blast furnace, based on the occurrence nearby of coking coal, providing an opportunity for the creation of an integrated iron and steel plant.

#### Summary of Hajigak deposit

- A world-class iron ore deposit.
- Estimated resource of 1.8 billion tonnes at approximately 62 % Fe.
- Sixteen ore bodies extending for up to 3 km and 100 m thick.
- Amenable to open pitting.
- Coal resource nearby suitable for blast furnace/smelting.



*Figure 7. Mixed magnetite and semi-martite iron ore.*

Soviet Category	Equivalent classification	Ore Type	Million tonnes	Fe%	S%
A	Measured or Proved	Oxidised ore	9.1	62.52	0.14
B		Oxidised ore	19.2	62.69	0.09
C1	Indicated or Probable	Oxidised ore	65.1	62.15	0.13
C1		Primary ore	16.2	61.3	4.56
C1		Fragmental ores	1.2	60.62	0.08
C2	Inferred or Possible reserves	All ore types	314.3		
C2		Fragmental ores	2.9		
P2	Hypothetical resources	All ore types	1333.3		
P2		Fragmental ores	8.6		
		Total	1769.9		

*Table 1. Iron resources at Hajigak identified following Afghan-Soviet exploration in the 1960s.*

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